IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Copy

In re Application of

David Stutsman

Serial No. 09/290,777

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For SPINDLE ASSEMBLY FOR MACHINE TOOLS AND METHOD OF MAKING SAME

Examiner Erica E. Cadugan

Art Unit 3722

APPEAL BRIEF UNDER 37 CFR §1.192

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(1) Real Party in Interest

The real party in interest in this case is Thermwood Corporation, P.O. Box 436, Dale, Indiana 47523.

(2) Related Appeals and Interferences

Applicant believes there are no pending appeals that have a direct relevance to the pending appeal.

(3) Status of Claims

Pending claims 1 and 3-20 are all finally rejected by the Office Action dated June 12, 2001. No claims are indicated to contain allowable subject matter.

(4) Status of Amendments

No after final amendments have been file subsequent to the Final Rejection.

(5) Summary of Invention

The invention provides for a spindle assembly for a machine tool comprising a housing having at least one bearing seat, a bearing having inner and outer races mounted in a bearing seat, a sleeve disposed between a race of the bearing and the housing, adhesively bonded to the housing, and a spindle mounted on the other race of the bearing wherein the spindle is axially aligned relative to the bearing and the spindle and bearing are displaceable axially relative to the sleeve rigidly secured to the housing. The assembly is formed by a method comprising forming a bearing seat in the housing, mounting the bearing on the spindle so that one of the races

mounting a spindle on one of an inner race and an outer race of a bearing;

mounting a sleeve on the other of said races of said bearing so that said bearing is displaceable axially relative to said sleeve;

applying an adhesive bonding material to at least one of a surface of said sleeve and a surface of said at least one bearing seat;

mounting said spindle with said bearing and sleeve, on said housing so that said surface of said sleeve is disposed adjacent to said surface of said bearing seat with said adhesive bonding material adjoining said surfaces; and

allowing said bonding material to set to rigidly secure said sleeve to said housing, permitting said bearing to displace along an axial line of travel relative to said sleeve.

12. A method according to Claim 11 including forming said at least one bearing seat slightly oversized relative to said sleeve.

13. A method according to Claim 12 wherein an amount of oversize is in a range between 0.010 to 0.015 inches.

14. A method according to Claim 11 including press fitting said inner race onto said spindle.

15. A method according to Claim 11 including:

forming first and second bearing seats in said housing;

mounting said spindle on one of an inner race and an outer race of a first bearing;

mounting a first sleeve on another one of said inner and outer races of said first bearing so that said first bearing is axially displaceable relative to said first sleeve;

applying an adhesive bonding material to at least one surface of said first sleeve and a surface of said first bearing seat;

mounting said spindle with said first bearing and first sleeve, on said housing so that said first sleeve is disposed adjacent said first bearing seat with said adhesive bonding material therebetween;

mounting a second sleeve on one of an inner and outer race of said second bearing so that said second bearing is axially displaceable relative to said second sleeve;

applying an adhesive bonding material on at least one of a surface of said second sleeve and a surface of said second bearing seat;

mounting another one of said inner and outer races of said second bearing on said spindle and said second bearing with said second sleeve in said second bearing seat with said adhesive bonding material between said second sleeve and said second bearing seat; and

allowing said adhesive bonding materials to set to rigidly secure said sleeves to said housing, permitting said bearings to displace along an axial line of travel relative to said spindle, relative to said sleeve.

16. A method of fabricating a spindle assembly for a machine tool comprising:

providing a housing having an opening therethrough with spaced, first and second enlarged sections providing outwardly facing annular seating surfaces and annular side walls;

mounting a first annular sleeve on an outer race of a first bearing so that said first bearing is axially displaceable relative to said first sleeve;

mounting said first bearing with said first sleeve disposed thereon onto a spindle having an annular seating surface so that an inner race of said first bearing seats on said annular seating surface of said spindle;

applying an adhesive bonding material to at least one of a surface of said first sleeve and the annular side wall of said first enlarged section of said housing opening;

inserting said spindle with said first bearing and first sleeve disposed thereon into said housing opening so that said first bearing is received in said first enlarged section, the outer race of said first bearing is seated on said annular surface of said first enlarged section and said annular sleeve is disposed adjacent the annular side wall of said first enlarged section with said adhesive bonding material disposed therebetween;

mounting a second annular sleeve on an outer race of a second bearing so that said second bearing is axially displaceable relative to said second sleeve;

applying an adhesive bonding material to at least one of a surface of said second sleeve and the annular side wall of said second enlarged section of said housing opening;

mounting said second bearing with said second sleeve disposed thereon, on said spindle disposed in said housing opening so that said second bearing is received in said second enlarged section, the outer race of said second bearing is seated on said annular surface of said second enlarged section and said second sleeve is disposed adjacent the annular side wall of said second enlarged section, with said adhesive bonding material disposed therebetween; and

allowing said adhesive bonding materials to set to rigidly secure said sleeves to said housing, permitting said spindle to displace along an axial line of travel relative to said housing.

17. A method according to Claim 16 wherein the inner races of said bearings are press fit onto said spindle.

18. A method according to Claim 16 wherein a spacer tube is provided on said spindle between the inner races of said bearings.

19. A method according to Claim 16 wherein a nut is threaded onto an end of said spindle for retaining said spindle and bearings within said housing opening.

20. A method according to Claim 16 wherein a cover plate is provided engaging the outer race of said first bearing.

(6) Issues

Group I

Whether claims 1 and 3-10 are unpatentable under 35 U.S.C. §103(a) as being rendered obvious by Nenninger (Pat. No. 1,761,841) in view of the *Machinery's Handbook*, 25th Ed., 1996.

Group II

Whether claims 11-20 are unpatentable under 35 U.S.C. §103(a) as being rendered obvious by Nenninger (Pat. No. 1,761,841) in view of the *Machinery's Handbook*, 25th Ed., 1996.

(7) Grouping of Claims

Group I: Claims 1 and 3-10 stand or fall together.

Group II: Claims 11-20 stand or fall together.

(8) Argument

The invention relates to an improved spindle assembly and a method to produce the same. Because the spindle of the present invention is run at up to 20,000 revolutions per minute (RPM), the bearing located in the bearing seats and the spindle must be accurately and axially

aligned. Otherwise, uneven loads will result in wobble during rotation which creates undo wear in the bearing seats, the roller balls, the spindle, and combinations of such components.

Under conventional methods of construction, the spindle assembly must be manufactured at very close tolerances to maintain the required axial alignment. This usually requires machining and grinding of the surfaces of the bearing seats which is very costly. The present invention reduces such cost by providing a spindle assembly and method of producing the spindle assembly without the need for such precise machining of the surfaces, while at the same time providing an accurately and axially aligned spindle, bearing, and bearing seat. The present invemtion uses a metal-to-metal bonding adhesive to bond a sleeve in a bearing seat between the bearing and the housing. This sleeve is placed in the housing before the bonding adhesive is set. Then the spindle assembly is assembled together, with the spindle, the bearings, and the bearing seats aligned axially, while the bonding agent sets to allow the sleeve to float between the bearing and the housing to make up for irregularities in the bearing seat. Once the bonding adhesive sets, the spindle and the bearings are accurately and axially aligned and the sleeve is bonded to the housing.

Group I

It would not be obvious to modify Nenninger (Pat. No. 1,771,841) as purportedly taught by the *Machinery's Handbook*, 25th ed., 1996 to arrive at the assembly defined in claims 1 and 3 through 10.

Applicant's invention provides for a bearing mounted on a spindle; a sleeve mounted on such bearing; the spindle, bearing and sleeve assembly being mounted in the spindle housing and a metal-to-metal adhesive injected between the sleeve and the housing to thus axial align the spindle, bearing and sleeve and allow the bearing and spindle to displace axially. This assembly

avoids the requirement of precision machining for such bearing seat. The sleeve moves into a position to act as the effective bearing seat, which provides perfect axial alignment between the spindle and the bearings. However, the prior art cited by the Examiner does not disclose such an assembly. The Nenninger reference discloses a spindle structure for a milling machine. The structure has a rigid bushing member locked into the housing. A portion of the bushing member is what defines the bearing seat (Nenninger Figure 5, item 73), not the housing. The portion of Nenninger which is the bearing seat according to the Examiner is really an aperture for fitting the bushing member (Nenninger Figure 5, item 71). The aperture in the housing does not define a bearing seat, it merely provides a location to place the bushing member. Further, the aperture and bushing member would necessarily require precision machining in order to maintain perfect axial alignment of the spindle and bearings which is precisely what Applicant's invention seeks to avoid.

Applicant's invention uses a bonding adhesive to allow the sleeve to float slightly during manufacturing to allow for axial alignment of the spindle and the bearings. When the bonding has set, the sleeve becomes a shim in the bearing seat to accomplish the axial alignment. The sleeve then becomes a permanent part of the housing via the adhesive. In contrast, the screw attached to the sleeve in Nenninger cited by the Examiner only locks the sleeve in its place, to prevent it from spinning with the spindle (Nenninger col. 4, lines 113-116). This definition of lock is stated in other embodiments of the spindle structure where other screws are used to lock the sleeve and prevent it from rotating, while at the same time allowing for the sleeve to move laterally along the axis of the spindle (Nenninger col. 3, lines 40-44). The Examiner's combination of the *Machinery's Handbook* and Nenninger merely provides for a replacement of screw with an adhesive, to prevent the bushing member from rotating. Neither Nenninger nor

the *Machinery's Handbook* disclose a sleeve between the bearing seat and the bearings to provide perfect axial alignment between the spindle and the bearings, rather both only disclose a bushing member containing a bearing seat bonded with an adhesive to a housing with no sleeve between the bearing seat and the bearings. Also, neither discloses or teaches permanently securing the bushing member via bonding adhesive, rather, the *Machinery's Handbook* only discloses replacing a screw with a bonding material.

Further, the Nenninger spindle mounting arrangement has been known for 70 years and metal to metal bonding has been known for at least 50 years, yet no one prior to Applicant has sought to apply the purported teachings of any metal to metal adhesive reference to the cited Nenninger arrangement to arrive at Applicant's claimed invention.

In summary, because Nenninger and the *Machinery's Handbook* do not disclose all the limitations of or teach a combination to arrive at Applicant's invention, the rejection of claims 1 and 3-10 should not be sustained.

Group II

It would not be obvious to modify Nenninger (Pat. No. 1,761,841) purportedly as taught by the *Machinery's Handbook*, 25th Ed., 1996 to arrive at Applicant's invention in claims 11 through 20.

The first step in the Applicant's method discloses forming at least one bearing seat in a housing. The Examiner cites Nenninger as disclosing a product which is necessarily made by such steps. However, Nenninger does not disclose a housing defining a bearing seat. Nenninger discloses an aperture for which a bushing member is fitted (Nenninger Figure 5, item 71), and such bushing member defines the bearing seat (Nenninger Figure 5, item 73). Thus, Nenninger

does not disclose a bearing seat in the housing and such assembly would not necessarily be produced according to Applicant's method.

Another step in Applicant's method discloses mounting the spindle, with the bearing and the sleeve, on the housing so that the surface of the sleeve is disposed adjacent to the surface of the bearing seat with the adhesive material adjoining both surfaces. This step necessarily implies the sleeve and the bearing seat being two components as the bonding material according to this step adjoins surfaces on the sleeve and bearing seat. As best disclosed in Nenninger, applying bonding material to adjoin the sleeve and the bearing seat is impossible. Not only is the enlarged bore in Nenninger (Nenninger Figure 5, item 73) the bearing seat for seating the bearing (Nenninger Figure 5, item 74), but it is also part of the sleeve as cited by Examiner (Nenninger Figure 5, item 70). Thus, the surface of the bearing seat and the surface of the sleeve adjacent to the bearing seat are the same surface, and thus cannot be bonded by any manner. Thus, this step cannot be used to produce the spindle assembly disclosed by the combination of Nenninger and the *Machinery's Handbook*, and there is no teaching in these references which teach such a step.

Further, although the *Machinery's Handbook* does teach that metal to metal adhesive bonding and the benefit of distributing load over an area rather than a concentrated area, it does not teach of dispensing with the precision machining and grinding of a bearing seat as would be required by Nenninger. Also, neither Nenninger nor the *Machinery's Handbook* teach of a method of obtaining concentricity of the spindle mounted in a bearing while dispensing with such precision machining and grinding. Nenninger necessarily requires such precision machining and grinding to maintain the spindle and bearing in axial alignment, and any combination with the *Machinery's Handbook* does not change this requirement of Nenninger. Applicant's method allows for the dispensing with such precision machining and grinding by a

method of mounting a spindle and a sleeve on a bearing to assure concentricity and axial alignment, this assembly is then positioned in a housing with the sleeve placed in opposing relation to a bearing seat, an adhesive is then injected between such sleeve and the opposed bearing seat, to secure the sleeve to the housing. This method assures axial alignment and concentricity of the spindle and the bearing.

As Nenninger and the *Machinery's Handbook* fail to disclose features necessarily created by the steps of Applicant's invention and do not disclose the method of or teach a combination to arrive at the method of Applicant's invention, the rejection of claims 11-20 should not be sustained.

(9) Conclusion

In accordance with the forgoing, it is submitted that the claimed invention is patentably distinguishable over the applied prior art of record and the rejection of claims 1 and 3-20 is erroneous. Therefore, reversal of this rejection is respectfully requested.

Respectfully submitted,

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(10) Appendix Claims

1. A spindle assembly for a machine tool comprising:

a housing having at least one bearing seat;

a bearing having an inner race and an outer race disposed in said at least one bearing seat;

a sleeve disposed between one of an inner and outer races of said bearing and said housing, bonded to said housing;

a spindle mounted on another one of the inner and outer races wherein said spindle is axially aligned relative to said bearing and said spindle and bearing are displaceable axially relative to said sleeve; and

wherein said sleeve is bonded to said housing with a metal-to-metal adhesive bonding material.

3. A spindle assembly according to Claim 1 wherein said material is an epoxy resin adhesive.

4. A spindle assembly according to Claim 1 wherein said spindle is provided with means for gripping a tool holder.

5. A spindle assembly according to Claim 1 wherein said housing includes a pair of spaced bearing seats in which there are disposed a pair of axially spaced bearings.

6. A spindle assembly according to Claim 1 wherein said housing is provided with an opening having an enlarged section defining said at least one bearing seat, the outer race of said bearing is disposed in said at least one bearing seat, said sleeve is disposed between said outer race of said bearing and said at least one bearing seat and is bonded to said housing and said spindle is received within said opening and journaled in the inner race of said bearing.

7. A spindle assembly according to Claim 6 wherein said sleeve is bonded to said housing with a metal-to-metal adhesive bonding material.

8. A spindle assembly according to Claim 6 wherein said enlarged section is provided with an annular wall, said sleeve is provided with an annular configuration, said outer bearing race is received within said annular sleeve and said annular sleeve is bonded to said annular wall of said enlarged section of said opening.

9. A spindle assembly according to Claim 6 wherein said spindle is provided with means for gripping a tool holder.

10. A spindle assembly according to Claim 6 wherein said opening in said housing includes a pair of spaced, enlarged sections defining bearing seats, and the outer race of the bearing is disposed in each of said bearing seats and a sleeve is disposed between each outer race of a bearing and an adjacent annular wall of an enlarged section of said housing .

11. A method of fabricating a spindle assembly for a machine tool comprising;

forming at least one bearing seat in a housing;

mounting a spindle on one of an inner race and an outer race of a bearing;

mounting a sleeve on the other of said races of said bearing so that said bearing is displaceable axially relative to said sleeve;

applying an adhesive bonding material to at least one of a surface of said sleeve and a surface of said at least one bearing seat;

mounting said spindle with said bearing and sleeve, on said housing so that said surface of said sleeve is disposed adjacent to said surface of said bearing seat with said adhesive bonding material adjoining said surfaces; and

allowing said bonding material to set to rigidly secure said sleeve to said housing, permitting said bearing to displace along an axial line of travel relative to said sleeve.

12. A method according to Claim 11 including forming said at least one bearing seat slightly oversized relative to said sleeve.

13. A method according to Claim 12 wherein an amount of oversize is in a range between 0.010 to 0.015 inches.

14. A method according to Claim 11 including press fitting said inner race onto said spindle.

15. A method according to Claim 11 including:

forming first and second bearing seats in said housing;

mounting said spindle on one of an inner race and an outer race of a first bearing;

mounting a first sleeve on another one of said inner and outer races of said first bearing so that said first bearing is axially displaceable relative to said first sleeve;

applying an adhesive bonding material to at least one surface of said first sleeve and a surface of said first bearing seat;

mounting said spindle with said first bearing and first sleeve, on said housing so that said first sleeve is disposed adjacent said first bearing seat with said adhesive bonding material therebetween;

mounting a second sleeve on one of an inner and outer race of said second bearing so that said second bearing is axially displaceable relative to said second sleeve;

applying an adhesive bonding material on at least one of a surface of said second sleeve and a surface of said second bearing seat;

mounting another one of said inner and outer races of said second bearing on said spindle and said second bearing with said second sleeve in said second bearing seat with said adhesive bonding material between said second sleeve and said second bearing seat; and

allowing said adhesive bonding materials to set to rigidly secure said sleeves to said housing, permitting said bearings to displace along an axial line of travel relative to said spindle, relative to said sleeve.

16. A method of fabricating a spindle assembly for a machine tool comprising:

providing a housing having an opening therethrough with spaced, first and second enlarged sections providing outwardly facing annular seating surfaces and annular side walls;

mounting a first annular sleeve on an outer race of a first bearing so that said first bearing is axially displaceable relative to said first sleeve;

mounting said first bearing with said first sleeve disposed thereon onto a spindle having an annular seating surface so that an inner race of said first bearing seats on said annular seating surface of said spindle;

applying an adhesive bonding material to at least one of a surface of said first sleeve and the annular side wall of said first enlarged section of said housing opening;

inserting said spindle with said first bearing and first sleeve disposed thereon into said housing opening so that said first bearing is received in said first enlarged section, the outer race of said first bearing is seated on said annular surface of said first enlarged section and said annular sleeve is disposed adjacent the annular side wall of said first enlarged section with said adhesive bonding material disposed therebetween;

mounting a second annular sleeve on an outer race of a second bearing so that said second bearing is axially displaceable relative to said second sleeve;

applying an adhesive bonding material to at least one of a surface of said second sleeve and the annular side wall of said second enlarged section of said housing opening;

mounting said second bearing with said second sleeve disposed thereon, on said spindle disposed in said housing opening so that said second bearing is received in said second enlarged section, the outer race of said second bearing is seated on said annular surface of said second enlarged section and said second sleeve is disposed adjacent the annular side wall of said second enlarged section, with said adhesive bonding material disposed therebetween; and

allowing said adhesive bonding materials to set to rigidly secure said sleeves to said housing, permitting said spindle to displace along an axial line of travel relative to said housing.

17. A method according to Claim 16 wherein the inner races of said bearings are press fit onto said spindle.

18. A method according to Claim 16 wherein a spacer tube is provided on said spindle between the inner races of said bearings.

19. A method according to Claim 16 wherein a nut is threaded onto an end of said spindle for retaining said spindle and bearings within said housing opening.

20. A method according to Claim 16 wherein a cover plate is provided engaging the outer race of said first bearing.

engages the spindle, mounting the sleeve on the other race of the bearing mounted on the spindle so that the bearing and the spindle are displaceable axially relative to the sleeve, applying a bonding material to at least one of a surface of the sleeve and a surface of the bearing seat, mounting the spindle with the bearing and sleeve as a unit on the housing so that such surface of the sleeve is disposed adjacent the surface of the bearing seat with the bonding material adjoining such surfaces and then allowing the bonding material to set to rigidly secure the sleeve to the housing.

Group I

1. A spindle assembly for a machine tool comprising:

a housing having at least one bearing seat;

a bearing having an inner race and an outer race disposed in said at least one bearing seat;

a sleeve disposed between one of an inner and outer races of said bearing and said housing, bonded to said housing;

a spindle mounted on another one of the inner and outer races wherein said spindle is axially aligned relative to said bearing and said spindle and bearing are displaceable axially relative to said sleeve; and

wherein said sleeve is bonded to said housing with a metal-to-metal adhesive bonding material.

3. A spindle assembly according to Claim 1 wherein said material is an epoxy resin adhesive.

4. A spindle assembly according to Claim 1 wherein said spindle is provided with means for gripping a tool holder.

5. A spindle assembly according to Claim 1 wherein said housing includes a pair of spaced bearing seats in which there are disposed a pair of axially spaced bearings.

6. A spindle assembly according to Claim 1 wherein said housing is provided with an opening having an enlarged section defining said at least one bearing seat, the outer race of said bearing is disposed in said at least one bearing seat, said sleeve is disposed between said outer race of said bearing and said at least one bearing seat and is bonded to said housing and said spindle is received within said opening and journaled in the inner race of said bearing.

7. A spindle assembly according to Claim 6 wherein said sleeve is bonded to said housing with a metal-to-metal adhesive bonding material.

8. A spindle assembly according to Claim 6 wherein said enlarged section is provided with an annular wall, said sleeve is provided with an annular configuration, said outer bearing race is received within said annular sleeve and said annular sleeve is bonded to said annular wall of said enlarged section of said opening.

9. A spindle assembly according to Claim 6 wherein said spindle is provided with means for gripping a tool holder.

10. A spindle assembly according to Claim 6 wherein said opening in said housing includes a pair of spaced, enlarged sections defining bearing seats, and the outer race of the bearing is disposed in each of said bearing seats and a sleeve is disposed between each outer race of a bearing and an adjacent annular wall of an enlarged section of said housing .

Group II

11. A method of fabricating a spindle assembly for a machine tool comprising;

forming at least one bearing seat in a housing;